

more disturbing dust, so that the turbidity increased inland toward the southwest, while seaward, to the north-east, there was decrease. (A second example of this in-

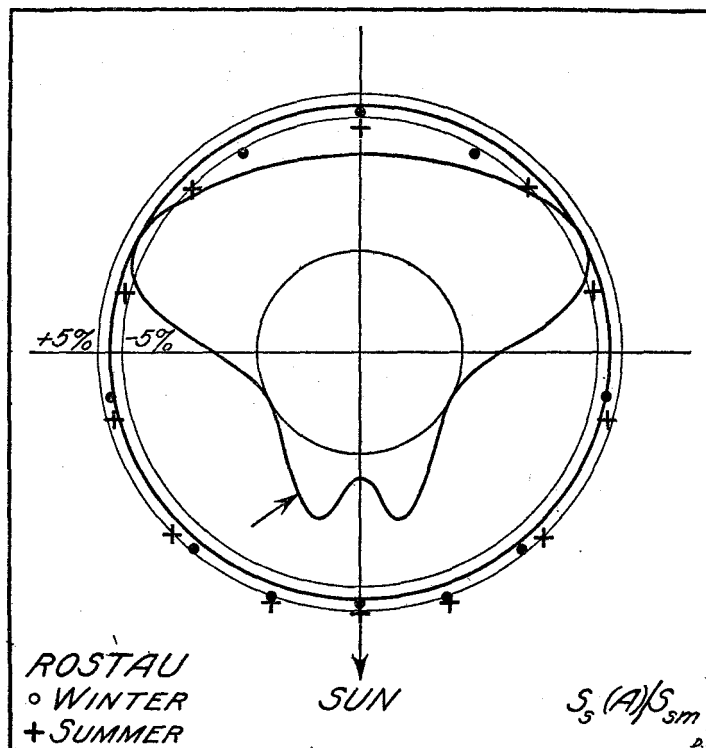


FIGURE 9.—Rostau winter and summer.

fluence of the northeast wind is furnished by a disturbed day.) In the five cases above named the turbidity on the contrary, plainly increased northward toward the city.

METEOROLOGICAL CONDITIONS ON THE SANTIAGO (CHILE)-BUENOS AIRES (ARGENTINA) AIRWAY

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[Translated from manuscript in French by W. W. Reed]

The increasing movement of international aerial traffic between the capitals of Chile and Argentina by airport and passenger companies has made evident the importance of meteorological studies of the regions crossed by aviators in their transcontinental flights over South America.

To give greater clearness to our study we divide the route from Santiago to Buenos Aires into three well-defined sections: The central region of Chile, the Andean region, and the central region of Argentina; and shall endeavor to summarize their meteorological conditions separately.

CENTRAL CHILE

The meteorological characteristics of this section vary with the seasons.

In summer, stability and continuity of atmospheric conditions predominate. The region of the central valley of Chile is warmed by the rays of the sun, and the temperature rises to 86° F., or higher, in the shade, consequently the air undergoes expansion and the pressure is lowered.

This decrease in pressure brings about a difference in pressure relative to the ocean and causes a southwest

We may then state the matter thus: According to measurements in an atmosphere that is horizontally homogeneous the relation $q = \frac{h_s}{h_h}$ is independent of the azimuth of the direction of sight relative to the sun's vertical.

IV. *The sighting distances.*—In conclusion let us reckon the mean values of $\Delta(A)$ in relative sighting distances $\frac{s_s(A)}{s_{sm}}$ according to Tables 1 and 2 and plot the results in polar coordinates as earlier with those of $\frac{q(A)}{q_m}$

We then obtain Figure 9. In this there are entered for comparison the results obtained by another investigation, namely, the curve indicated by the arrowhead. It is perceived at first sight how slight are the deviations from theory now found in our Danzig measurements, even though in the values here used the influence of reflected light is not eliminated. The fact that the Danzig results so nearly approach theory has its basis first of all in the careful selection of the place of observation, one where nonhomogeneities of the air were especially avoided in the use of a strongly defined object, and in the application of the photometric process.

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wind, generally called "travesia, or cross-wind," which blows with greater force in the transverse valleys of the watercourses. The régime of this wind is simple: it begins near midday, acquires its maximum force between 2 p. m. and 4 p. m., and falls away toward sunset. During the night and the morning there is calm or the wind blows in light breezes from north or northwest.

The "travesia" is a surface wind. Aerological soundings show that its maximum intensity is observed to a height of 500 meters; toward 1,500 meters it falls away and there is a belt with variable wind or calm; then at about 2,000 meters and up to 3,000 meters, according to the season, there are found constant northwest winds. During the summer, cloudiness is a minimum in the interior of central Chile, and visibility is good; however, there generally forms along the coast a stretch of fog, 30 to 40 kilometers wide, and also stratus cloud, both of which dissipate toward noon.

In winter the meteorological conditions in central Chile change completely. The atmospheric régime is characterized by instability; scarcely does the anti-cyclonic régime set in with fine, cold weather and south wind when there appears a cyclonic régime with unsettled weather, north wind, and rain. These changes may be studied on our daily meteorological charts.

The upbuilding of an anticyclonic center leads to different consequences according to the position of the high pressure.

If the center of the high pressure is over Coquimbo or in the region of Aconcagua, the sky is generally covered with stratus, alto-stratus, cumulo-stratus, or alto-cumulus clouds. These different types appear in succession at different heights from 300 to 4,000 meters. Northwest winds predominate up to 5,000 or 6,000 meters, or are displaced by the normal currents from the west.

The second case is presented when the anticyclonic center has its barometric maximum over the ocean in the vicinity of the Juan Fernandez Islands; then west winds prevail and the weather is variable.

Lastly, the third case appears when the center of high pressure is found in the south; then the weather is set fair, with south wind and good visibility.

The coming of the cyclonic depression has different consequences according to the latitude of the center of low pressure. When it approaches from the northwest in the latitude of Coquimbo weather conditions change little in the central region of Chile; south winds prevail and high clouds, cirrus, cirro-stratus, and cirro-cumulus, partially cover the sky.

When the center of low pressure is shifted toward the Juan Fernandez Islands or comes directly from the west, the cloudiness is marked; the sky is covered with high stratus and nimbus, the wind blows from the north, and rain is possible.

Lastly, in the third case, when the center of low pressure passes south of the central section, foul weather is certain. At the surface there are strong north winds with rain; at 6,000 meters the winds are from northwest, and at 8,000 meters from the west. The layer of nimbus bringing the rain may lie between 300 and 2,000 meters, covering the mountains; above this layer of cloud there is generally another of high stratus of variable thickness. The sun shines between the latter thin clouds and those of the cirrus type.

In autumn and spring, meteorological régimes alternate; periods of stability are followed by the arrival of anticyclonic centers and cyclonic depressions. The period of rains generally extends from April to October.

From this summary of the meteorological studies of the central region of Chile there may be deduced some conclusions interesting in aviation: At the surface the prevailing winds blow from the southwest, and the landing fields should be oriented so that their major axes lie in that direction; the pilots can fly low and take advantage of the surface winds when going north, or they can fly high and make use of the higher currents when going south; then, too, an experienced pilot can fly through the bad weather of winter by taking advantage of the different cyclonic and anticyclonic currents, which change direction according to elevation, and by rising above the different cloud ceilings and fixing his course by astronomical navigation.

ANDEAN REGION

The region of the cordillera is, without doubt, the most difficult and the most dangerous for aerial navigation; and for this reason merited from the beginning a special study, mainly through the installation of a private observatory at Caracoles, and, later, of a new observatory at Portillo at an elevation of 3,000 meters.

In order to cross the cordillera through the Pass of Uspallata the aviator must rise to a mean elevation of

5,000 meters. In this region there are peaks like Tupungato and Aconcagua with heights varying between 6,000 and 7,000 meters.

The diminution in atmospheric pressure produces different effects: (1) The density of the air being less, the power of the airplane is reduced to one-half or one-third, and the machine does not respond with the same precision as at the level of the central valley. This decrease can be calculated in percentage, taking into consideration the pressure, which is reduced from 10,333 kilograms per square meter at the level of the sea to less than 4,000 kilograms per square meter at these elevations. (2) The decrease in atmospheric pressure brings marked physiological effects upon the pilot and the passengers. If arterial pressure is not properly counteracted by atmospheric pressure hemorrhages may take place in the less resistant parts of the bodies of persons affected by hypertrophy or whose blood pressure is high (generally those of advanced age). At first the action of the heart is accelerated, then it is gradually lowered as a result of mountain sickness; respiratory action is accelerated, and, at length, the combined action of diminished pressure and cold, mainly in the time of snow and in an open plane, produces asthenia with all its consequences. Under such conditions the maintenance of will power to maneuver a plane becomes difficult.

After this brief comment on mountain sickness produced by abrupt variations in meteorological conditions, we proceed to the study of the atmospheric régime prevailing in the cordillera of the Andes.

Meteorological observations have been made for more than a year at the observatory of Caracoles, situated near the culminating point of the Pass of Uspallata at an elevation of 3,200 meters.¹

The régime of the surface winds that blow in the massifs of the Andes is different from that found in the winds aloft, above 3,200 meters. While at this altitude prevailing winds come from the west during the entire year, on the other hand at Rio Blanco, Juncal, and Portillo there is observed every day, and especially in summer, a strong breeze from the west, which comes up about 10 a. m., reaches its maximum during the afternoon, and falls away at sunset. During the night the weather is generally calm. This regular régime of the winds is, of course, totally disarranged by storms.

Available statistical data permit the presentation of a general idea of the atmospheric conditions prevailing at these altitudes where observation and study have not been conducted in regular and methodical manner.

On account of the magnitude of the undertaking the crossing of the cordillera is not to be compared with the passage over the Pyrenees or over the Alps. Above its snowy summits there blow winds of such violence that they are able to impede the progress of the swiftest airplane, and it must not be forgotten that the power of the motors is reduced to less than one-half at these altitudes. In addition, the clouds covering the sides of the mountains and the snows hiding the ends of the craft from the pilot's view are important factors that must be taken into account in the aerial navigation of these regions.

During storms the different layers of cloud that form on the sides of the mountains group themselves between 1,000 and 5,000 meters; if an airplane from Mendoza bound for Santiago succeeds in rising above the clouds, the aviator will see the entire central region of Chile, from the cordillera to the sea, covered with a uniform

¹ The author's tabulation is omitted on account of the shortness of the record; a longer series of observations may modify the results considerably.

white blanket. The locating of landing fields under such conditions is a problem not yet solved.

The "air holes" that are observed in the cordillera may be of two classes: Those of thermal origin and those of dynamic origin.

The former are generally encountered in summer; the bases of the cordillera are warmed more than the snowy summits, and there results a difference in density which causes the aviator to lose elevation.

The latter are generally met with in winter, and are much more intense phenomena; the strong winds from north or west become engulfed in the deep valleys that separate the mountains and form violent whirls. The centrifugal force developed lowers the pressure in the center, diminishing the density of the air to such an extent as to cause the fall of the airplane.

These air holes occurring in the mountainous regions can be closely studied by means of soundings with equally inflated balloons and also by means of the statoscope.

In view of the fact that these dangerous zones are due to the topography of the region, it would be easy to make navigation charts in which there would be indicated, section by section, the meteorological conditions in the cordillera. In order to do this it is necessary to establish a systematic plan of aerial soundings, and to have well distributed observing stations in charge of an alert and competent personnel.

The conclusions from these studies are of inestimable value in aerial navigation. It is only with a complete knowledge of meteorological conditions in the cordillera of the Andes that pilots will be able to avoid the elements of nature and even to use them in increasing the safety of flights.

The cooperation of the different aviation companies with the Government of Chile and Argentina is necessary for the undertaking of the studies on the two sides of the Andes.

CENTRAL REGION OF ARGENTINA

This region presents meteorological characteristics entirely different from those noted in the central region of Chile. Rains and storms occur in any and all periods of the year, but more generally in summer, and the development followed in the meteorological phenomena is very different.

Generally after two or three days of marked warmth in central Argentina, the air expands and the pressure lowers, forming a decided continental depression of thermal origin, whose center is frequently situated between Mendoza, San Juan, and Cordoba.

If, under these conditions, an anticyclonic center moving from southern Chile penetrates Argentina through Neuquen, and advances along the Atlantic coast, there is produced a strong barometric gradient between the area of high pressure (polar) and the area of low pressure (equatorial).

This difference in pressure, intensified by the advance of anticyclonic air toward the stationary depression, gives rise to a violent southeast² wind, the "pampero," or wind

of the pampa, a surface wind which may be avoided by flying at a great height.

The cold air of the polar front, more dense and consequently heavier, penetrates like a wedge under the warm, less dense, and therefore lighter, air of the continental depression. The latter is forced to rise and there are formed violent convectional currents, which are cooled on rising into higher regions. This cooling lowers the point of saturation and the water vapor condenses into clouds, of which the predominant form is cumulo-nimbus, very dangerous in aviation. Lightning, thunder, and heavy downpours or hail, accompany the pampero.

The depression takes a V form and moves obliquely toward the Atlantic coast; the line of discontinuity is, in this case, well marked. The storm conditions can recur during warm hours on several successive days at different points in the direction of advance.

During winter atmospheric conditions in the central region of Argentina are usually more stable.

From this brief analysis of meteorological conditions in central Argentina, it appears that in any period of the year, and especially in summer, air pilots may be exposed to accidents of meteorological origin, both through the drift caused by the strong winds, the "pampero" and the "zonda," and through the strong convection currents developing during storms. The danger of fire from continuous electrical discharges in the stormy regions is problematical.

With a complete knowledge of meteorological conditions in the regions over which flight is made, all of these phenomena can be avoided and the safety of the course increased.

CONCLUSIONS

From this study it develops that the three sections found along the route from Santiago to Buenos Aires have characteristics meteorologically different, and that for the development of regular flights it is necessary to have a good meteorological service to the end that pilots, at any time whatever, may be informed in a general way of atmospheric conditions along their routes. This, with the indispensable knowledge that every pilot must possess, will contribute effectively to the reduction of accidents in aviation.

At each aviation base along the route there should be a meteorological station with its radio-telegraphic station in order that there may be uninterrupted communication with the other stations along the route.

It is very necessary to bring about international cooperation between the meteorological services of Chile and Argentina, and, especially, to get assistance from the aviation companies profiting most directly from these services.

Another very important matter is the transmission of meteorograms by the different South American stations at fixed hours, to the end that the formation and development of the different meteorological phenomena may be followed daily, and their advances over the continent foreseen.

² It may be that the author inadvertently used the word "sud-est" where "sud-ouest" was intended.—Ed.